# CHAPTER 24

# Hearing

## KEY TEACHING POINTS

- Hearing loss is a common problem in older patients, one often overlooked unless specific testing is performed.
- Three bedside tests accurately detect hearing loss: the whispered voice test, finger rub test, and ticking watch test.
- After hearing loss is identified, tuning fork tests (i.e., Weber and Rinne tests) help to distinguish neurosensory from conductive hearing loss. Having bone conduction greater than air conduction (during the Rinne test) greatly increases the probability of a conductive hearing loss.

## I. INTRODUCTION

Hearing loss, which affects 25% to 40% of individuals over the age of 65, is associated with depression, difficulty communicating, and reduced mobility.[1] Clinicians using casual assessment in the office overlook significant hearing loss approximately half the time.[2] The causes of hearing loss are either **neurosensory** (i.e., damage to the auditory nerve or cochlear hair cells) or **conductive** (i.e., damage to the parts of the ear that conduct sound from air to the cochlea). Most neurosensory hearing loss is due to presbyacusis (the degenerative hearing loss of aging). Less common causes are Meniere disease and acoustic neuroma. The most common causes of conductive loss are impacted cerumen, otitis media, perforated eardrum, and otosclerosis.[1]

## II. TECHNIQUE

### A. WHISPERED VOICE TEST

Many tests of hearing are available to general clinicians, some more formal (handheld audiometer) than others (listening to whisper, watch, finger rub, or tuning fork). One validated test not requiring special tools is the whispered voice test. In this test the clinician whispers a combination of three letters or numbers (e.g., 5, B, 6) while standing at arm's length (i.e., approximately 2 feet) behind the patient and then asks the patient to repeat the sequence. If the patient answers correctly, hearing is considered normal and testing is stopped. If the patient misidentifies any of the three items, the clinician repeats different triplets of numbers or letters 1 or 2 more times. If 50% or more of the items in the two or three triplets are incorrect, the test is abnormal.

The clinician stands behind the patient to prevent lip-reading. Only one ear is tested at a time, the other being masked by the examiner's finger, which occludes

the external auditory canal and makes continuous circular rubbing motions (occlusion without rubbing is insufficient masking). The clinician should quietly exhale before whispering to produce the quietest whisper possible.[3]

## B. FINGER RUB TEST

The clinician stands directly in front of the patient with outstretched arms and tests one ear at a time by rubbing thumbs against the distal fingers (Fig. 24.1).[4] During the test the patient has the eyes closed and is encouraged to listen carefully to indicate on which side the rubbing is heard by raising the ipsilateral arm. A *strong* finger rub is as loud as the clinician can muster without snapping the fingers; a *faint* rub is the softest the clinician can still hear. *Inability* to hear the finger rub is "test positive."

## C. TICKING WATCH TEST

The clinician positions a ticking watch 6 inches away from the patient's ear while the patient occludes the opposite ear. The test is repeated 6 times, and inability to hear the ticking sound during any of these trials is a positive test.[5] To prevent providing visual clues, the clinician should test the patient from behind or ask the patient to close his or her eyes.

## D. TUNING FORK TESTS

### 1. INTRODUCTION

After hearing loss is identified, tuning fork tests distinguish neurosensory from conductive loss. All tuning fork tests are based on the same fundamental principle,

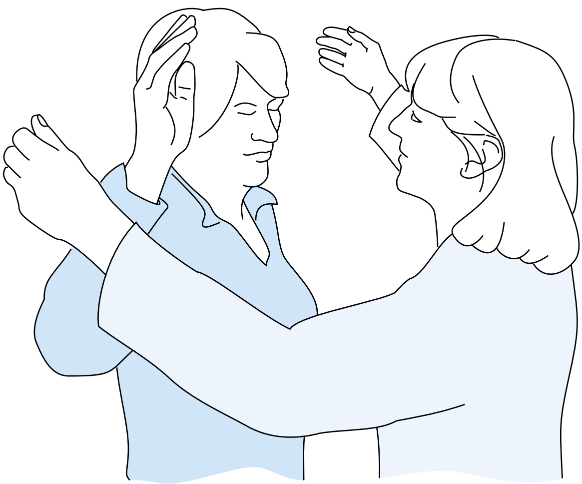

**FIG. 24.1 FINGER RUB TEST.** In this illustration the clinician is testing the patient's right ear, and the patient indicates by raising the right arm that the sound of the finger rub is perceived (i.e., "test negative," defined as the patient *can* hear the finger rub). In the original study of this finding,[4] each ear was tested 3 times (with both faint and strong stimuli), and "cannot hear finger rub" was defined as failure to hear any of the three stimuli. Because the patient must raise the arm indicating the side the stimulus is heard, masking the untested ear is unnecessary (i.e., if the right ear is being tested in a patient with severe unilateral right hearing loss, the clinician will be able to detect that the unmasked left ear is detecting the sound because the left arm is raised).

discovered almost 500 years ago:* sound conducts preferentially through bone to ears with disease causing conductive hearing loss. Tuning fork tests were introduced into clinical otology in the early 1800s, and at one time there were more than 15 distinct tuning fork tests.[7] After introduction of audiometry, however, enthusiasm for tuning fork tests waned, and now only two are commonly used, the Weber and Rinne tests.

## 2. THE FREQUENCY OF THE TUNING FORK

Most authorities recommend using the 512-Hz tuning fork for tuning fork tests,[8] because frequencies above 512-Hz detect conductive hearing loss less well and because frequencies of 128-Hz or lower generate so many vibrations that even patients without hearing can sense them.[9-11] The 512-Hz fork is preferred to the 256-Hz fork because the 256-Hz fork produces more fals-positive results in some studies.[12,13]

## 3. METHOD OF STRIKING THE FORK

Most authorities recommend striking the fork against a soft surface, such as a rubber pad or the muscles of the forearm.[8] The principal tone produced is the same whether the tines are struck on a soft or harder surface, but the harder surface generates multiple overtones that may confound interpretation by the patient.[7] Weights, sometimes added to the tines to minimize overtones, also shorten the time of vibration and are not recommended.

## 4. WEBER TEST

In the Weber test the clinician strikes the fork, places it in the middle of the patient's vertex, forehead, or bridge of nose, and asks "Where do you hear the sound?" (Fig. 24.2). In patients *with unilateral hearing loss* the sound is preferentially heard in the *good* ear if the loss is neurosensory and in the *bad* ear if the loss is conductive.[8,14] Weber himself recommended placing the vibrating fork on the incisors[15] and subsequent studies do show this is the most sensitive technique,[16] although concerns of transmitting infectious diseases now prohibit this method.

According to traditional teachings, persons with normal hearing perceive the sound in the midline or inside their head, but studies show that up to 40% of normal-hearing persons also lateralize the Weber test.[11] Therefore the Weber test should be interpreted only in patients with hearing loss.

## 5. RINNE TEST

In the Rinne (pronounced "RIN-neh") test, the clinician tests each ear individually to determine whether that ear detects sound better through air or bone (see Fig. 24.2). Air conduction (AC) is tested by holding the vibrating fork approximately 2.5 cm away from the ear, with the axis joining the tips of the tines in line with the axis through both external auditory canals.† Bone conduction (BC) is

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*The Italian physician Capivacci made this discovery after connecting his subject's teeth to a zither and then plucking the zither's strings.[6]

†During air conduction, the orientation of the tines of the fork is important because sound waves emanate in two directions from the fork: one direction parallel to the axis of the tines and the other perpendicular to it. If the tines are held at an oblique angle, these sound waves may actually cancel each other out and diminish the sound.[7] Clinicians can easily convince themselves of this by rotating the stem of a vibrating fork near their own ear, noting that the sound intermittently disappears.

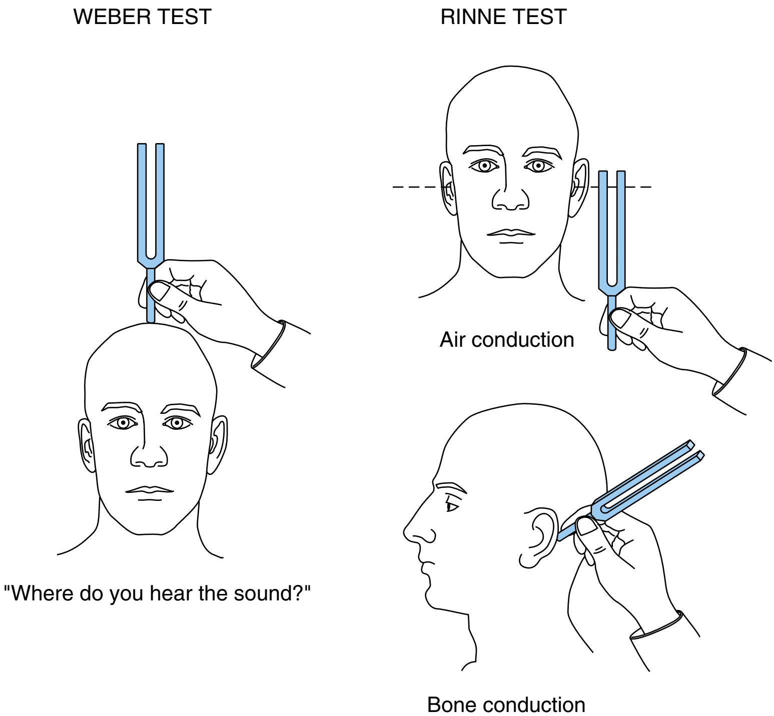


**FIG. 24.2 WEBER AND RINNE TUNING FORK TESTS.** In the Weber test (*left*) the clinician holds the vibrating tuning fork in the midline against the patient's vertex, forehead, or bridge of nose and asks "Where do you hear the sound?" In the Rinne test (*right*) the clinician tests one ear at a time, comparing perception of sound conducted through air (*top right*) to perception of sound conducted through bone (*bottom right*). When testing AC, the tuning fork is held so that an axis through both external auditory canals (*dashed line*) passes through both tines of the fork. When testing BC, the stem of the vibrating fork is held against the mastoid.

tested by holding the stem of the vibrating fork against the mastoid (excessive force should be avoided because it diminishes the test's specificity).[17] There are two methods for comparing AC and BC: (1) loudness comparison technique, in which the fork is held approximately 2 seconds in each position, and the patient indicates which position is louder, and (2) threshold technique, in which the clinician uses a stopwatch to time how long the patient hears the sound, from the moment the fork is struck to when the sound disappears, first for AC and then BC.[8]

Patients with normal hearing or neurosensory hearing loss perceive sound better (i.e., louder or longer) through AC than through BC, whereas those with conductive hearing loss perceive it better through BC; according to a confusing tradition, this result (bone better than AC) is recorded "Rinne negative," although it is more explicit to record "BC > AC" for the abnormal result.

Table 24.1 presents examples of different Weber and Rinne test results and possible interpretations.

**TABLE 24.1 Tuning Fork Tests—Traditional Interpretation**

| Weber Test | Rinne Test | Possible Interpretations |
|---|---|---|
| Midline | AC > BC, bilateral | 1. Normal hearing, bilateral<br>2. Neurosensory loss, bilateral |
| Louder in left | BC > AC, left<br>AC > BC, right | 1. Conductive loss, left |
| Louder in left | AC > BC, bilateral | 1. Normal hearing, bilateral<br>2. Neurosensory loss, worse on right |
| Louder in right | BC > AC, bilateral | 1. Conductive loss, bilateral but worse on right<br>2. Conductive loss on right and severe neurosensory loss on left* |

*Some patients with severe neurosensory loss have the finding BC > AC because the BC stimulus is cross-heard by the better cochlea on the nontest side.
*AC*, Air conduction; *BC*, bone conduction.
Based upon reference 8.

# III. CLINICAL SIGNIFICANCE

## A. WHISPERED VOICE TEST

EBM Box 24.1 reveals that the abnormal whispered voice test accurately increases the probability of significant hearing loss (i.e., >30 dB; likelihood ratio [LR] = 6.0) and the normal test practically excludes significant hearing (LR = 0.03).

## B. FINGER RUB TEST

In a study of 221 outpatients to a neurology clinic the *inability* to hear the *strong* finger rub is pathognomonic for hearing loss (LR = 355.4), whereas the *ability* to hear the *faint* finger rub indicates the patient's hearing was normal on that side (LR = 0.02).

## C. TICKING WATCH TEST

In one study of 107 patients the inability to hear the ticking watch was a compelling argument for hearing loss (LR = 105.7).

## D. TUNING FORK TESTS

Using the loudness comparison technique, the Rinne test accurately detects conductive hearing loss. The finding of "BC > AC" increases the probability of an audiometric air-bone gap more than 20 dB (LR = 16.8; see EBM Box 24.1); the finding of "AC > BC" decreases the probability of an air-bone gap this large (LR = 0.2). The larger the patient's air-bone gap on audiometry, the more likely the Rinne test will reveal "BC > AC" (for comparison, the mean air-bone gap in otosclerosis and otitis media is 21 to 27 dB).[13,19,20]

On the other hand, the Weber test is less accurate. When the sound lateralizes to the good ear in patients with unilateral hearing loss, the probability of neurosensory hearing loss increases only a small amount (LR = 2.7). The Weber test performs poorly because many patients with unilateral hearing loss, whether neurosensory or conductive, localize the tuning fork sound in the midline.[11]

## EBM BOX 24.1
### *Hearing Tests**

| *Finding (Reference)*† | *Sensitivity (%)* | *Specificity (%)* | **Likelihood Ratio‡ if Finding Is** *Present* | *Absent* |
|---|---|---|---|---|
| ***Hearing Tests*** | | | | |
| Abnormal whispered voice test[2,3,18] | 90-99 | 80-87 | **6.0** | **0.03** |
| Unable to hear strong finger rub[4] | 61 | 100 | **355.4** | 0.4 |
| Unable to hear faint finger rub[4] | 98 | 75 | **3.9** | **0.02** |
| Unable to hear ticking watch[5] | 44 | 100 | **105.7** | 0.6 |
| ***Tuning Fork Tests (Patients With Unilateral Hearing Loss)*** | | | | |
| Rinne test, detecting conductive hearing loss[13,19] | 60-90 | 95-98 | **16.8** | **0.2** |
| Weber test lateralizes to good ear, detecting neurosensory loss[11] | 58 | 79 | 2.7 | NS |
| Weber test lateralizes to bad ear, detecting conductive loss[11] | 54 | 92 | NS | 0.5 |

*Diagnostic standard: for *hearing loss* mean pure tone threshold >25 dB (finger rub test, ticking watch) or >30 dB (whispered voice test) on audiometry; for *conductive hearing loss (Rinne test)*, air-bone gap on audiometry ≥20 dB.

†Definition of findings: for *abnormal whispered voice test* and *finger rub test,* see text; for *Rinne test,* bone conduction (BC) greater than air conduction (AC), using the loudness comparison technique; all tuning fork tests used 512-Hz tuning fork.

‡Likelihood ratio (LR) if finding present = positive LR; LR if finding absent = negative LR.

*NS*, Not significant.

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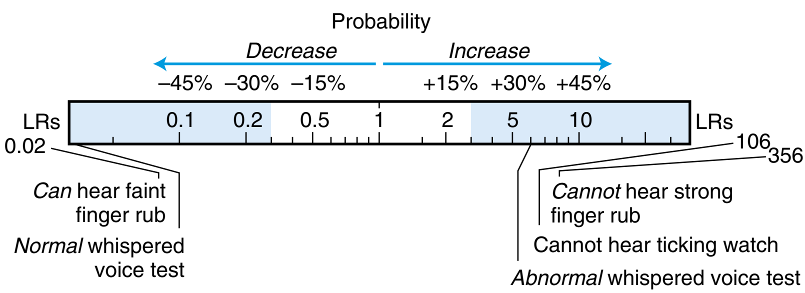
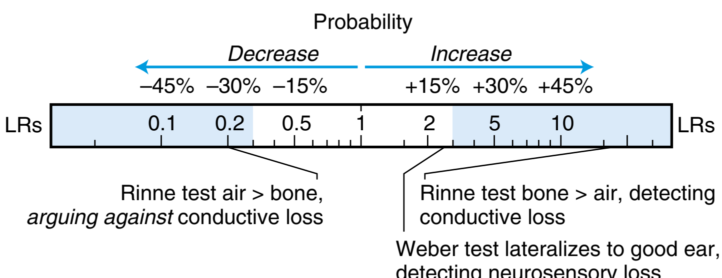
**SIGNIFICANT HEARING LOSS**




**TUNING FORK TESTS**



Tuning fork tests cannot distinguish normal hearing from bilateral neurosensory losses (see Table 24.1) and thus should always follow hearing tests. Moreover, tuning fork tests cannot distinguish a pure conductive loss from a mixed conductive and neurosensory defect (see Table 24.1).

*The references for this chapter can be found on www.expertconsult.com.*

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